

CLAIMS

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What is claimed is:

1. A method, comprising:
receiving one or more demands for service in a mesh network comprising a plurality
of nodes interconnected by a plurality of links; and
10 mapping each of the one or more demands onto a primary path and a restoration path
in the network to generate a path plan for the one or more demands in the network,
wherein reduction of a portion of restoration time associated with failure-related cross-
connections in the network is taken into account during the mapping.
- 15 2. The invention of claim 1, wherein a maximum number of failure-related cross-
connections at all nodes in the network is less than a specified threshold.
3. The invention of claim 1, wherein the mapping results in a maximum number of
failure-related cross-connections at all nodes in the network being within a specified
20 tolerance of a theoretical minimum.
4. The invention of claim 3, wherein a graph-theoretic condition is used to derive the
theoretical minimum.
- 25 5. The invention of claim 4, wherein the theoretical minimum is defined by
 $\max_{n \in N} \{\lceil \delta_n / d_n \rceil\}$ where n , a node in the network, is an element of N , the set of all nodes in
the network, δ_n is the number of unit demands terminated on node n , and d_n is the number of
edges incident on node n .
- 30 6. The invention of claim 1, wherein the mapping sequentially evaluates each
possible path plan for each of the one or more demands and selects the path plan having a
smallest maximum number of failure-related cross-connections.
7. The invention of claim 1, wherein the mapping comprises:
35 selecting two node-disjoint paths for each demand, wherein leveling of link loads is
taken into account during the selecting; and

5 for each demand, identifying one of the two node-disjoint paths as the primary path and the other as the restoration path, wherein a maximum number of failure-related cross-connections at all nodes in the network is taken into account during the identifying.

8. The invention of claim 7, wherein:
10 selecting the two node-disjoint paths for each demand minimizes maximum link bandwidth in the network; and
 identifying the primary and restoration paths for each demand results in the maximum number of failure-related cross-connections at all nodes in the network being within a specified tolerance of a theoretical minimum.

15 9. The invention of claim 8, wherein a tent pole condition is used to derive the theoretical minimum.

20 10. The invention of claim 7, wherein mixed-integer programming is used in each of the selecting and the identifying.

 11. The invention of claim 7, wherein genetic programming is used in each of the selecting and the identifying.

25 12. The invention of claim 7, wherein a commercial solver is used in each of the selecting and the identifying.

30 13. The invention of claim 1, wherein the mapping involves demand bundling, wherein demands having a common source node and a common destination node are grouped and routed along a single pair of disjoint primary and restoration paths and at least a portion of connection signaling for the group is carried out jointly.

35 14. The invention of claim 1, wherein the mapping involves traffic aggregation, wherein multiple low-rate channels in the network are consolidated into a high-rate channel and rerouting of the high-rate channel requires fewer cross-connections than rerouting of the multiple low-rate channels.

5 15. A network manager for a mesh network comprising a plurality of nodes interconnected by a plurality of links, the network manager adapted to:
receive one or more demands for service in the network; and
map each of the one or more demands onto a primary path and a restoration path in
the network to generate a path plan for the one or more demands in the network, wherein
10 reduction of a portion of restoration time associated with failure-related cross-connections in the network is taken into account during the mapping.

16. The invention of claim 15, wherein a maximum number of failure-related cross-connections at all nodes in the network is less than a specified threshold.

15 17. The invention of claim 15, wherein the path plan results in a maximum number of failure-related cross-connections at all nodes in the network being within a specified tolerance of a theoretical minimum.

20 18. The invention of claim 17, wherein a graph-theoretic condition is used to derive the theoretical minimum.

19. The invention of claim 18, wherein the theoretical minimum is defined by:
 $\max_{n \in N} \{\lceil \delta_n / d_n \rceil\}$ where n , a node in the network, is an element of N , the set of all nodes
25 in the network, δ_n is the number of unit demands terminated on node n , and d_n is the number of edges incident on node n .

20. The invention of claim 15, wherein the network manager sequentially evaluates each possible path plan for each of the one or more demands and selects the path plan
30 having a smallest maximum number of failure-related cross-connections.

21. The invention of claim 15, wherein the network manager is adapted to:
perform selection of two node-disjoint paths for each demand, wherein leveling of link loads is taken into account during the selection; and
35 identify, for each demand, one of the two node-disjoint paths as the primary path and the other as the restoration path, wherein a maximum number of failure-related cross-connections at all nodes in the network is taken into account during the identifying.

5 22. The invention of claim 21, wherein:

selection of the two node-disjoint paths for each demand minimizes maximum link bandwidth in the network; and

identifying the primary and restoration paths for each demand results in the maximum number of failure-related cross-connections at all nodes in the network being within a
10 specified tolerance of a theoretical minimum.

23. The invention of claim 22, wherein a graph-theoretical result is used to derive the theoretical minimum.

15 24. The invention of claim 22, wherein mixed-integer programming is used in each of the selection and the identifying.

25. The invention of claim 22, wherein genetic programming is used in each of the selection and the identifying.

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26. The invention of claim 22, wherein a commercial solver is used in each of the selection and the identifying.

27. The invention of claim 15, wherein the network manager is adapted to consider
25 demand bundling in generation of the path plan, wherein demands having a common source node and a common destination node are grouped and routed along a single pair of disjoint primary and restoration paths and at least a portion of connection signaling for the group is carried out jointly.

30 28. The invention of claim 15, wherein the network manager is adapted to consider traffic aggregation in the generation of the path plan, wherein multiple low-rate channels in the network are consolidated into a high-rate channel and rerouting of the high-rate channel requires fewer cross-connections than rerouting of the multiple low-rate channels.